January 2000 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

High-Intensity Distributed Phase Plates: We are developing continuous distributed phase plates (DPP's) to produce a target irradiance of between 1.5 to 2.0 $\times$ 10^{15} W/cm^2 per beam. While the DPP's used for spherical targets produce a 930-μm-diam focal spot, the new DPP's will produce a much smaller, 200-μm-diam focal spot. For this application of DPP's, the phase front of the laser beam plays a much greater role in determining the size and shape of the focal spot. An accurate phase-front characterization of the laser beamline is vital to irradiance modeling and DPP design. Recently, the OMEGA wavefront sensor (OWS), which incorporates an ultraviolet interferometer, was used to measure the phase front of one of OMEGA's frequency-tripled laser beams. Figure 1(a) shows an interferogram of a 27-cm-diam laser beam. Spatial synchronous phase detection (SSPD) is performed to produce the phase front shown in Fig. 1(b). The peak-to-valley phase error is approximately five waves, and the rms phase error is about one wave. The Fourier transform of the measured phase front yields the phase-induced focal spot of the laser beam shown in the two side lobes of Fig. 1(c). This aberrated focal spot has a mean diameter of approximately 50 μm, which corresponds to a 10$\times$-diffraction-limited laser beam. Additional modeling shows that although laser-beam aberrations of this magnitude do not affect the fidelity of phase conversion for a 930-μm target used in direct-drive ICF experiments, much smaller, 200-μm-diam focal spots would be significantly affected.

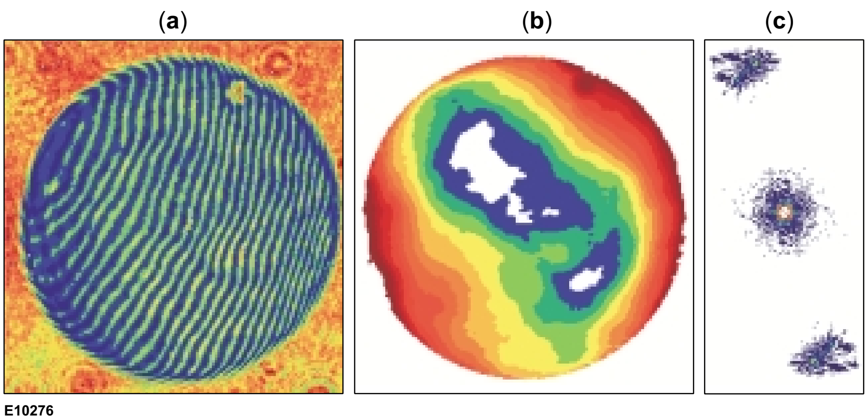

Figure 1. (a) Interferogram of an OMEGA beam. (b) OMEGA wavefront deduced by SSPD. Each color interval represents one-half wave at 351 nm. (c) Fourier transform of measured wavefront.

CCD-Based Diagnostics in High-Neutron Environments: Charge-coupled-device (CCD) detectors are replacing film as the recording medium in many ICF diagnostics. Unfortunately, in the presence of high levels of neutrons, CCD's experience an enhanced background level. This background degrades the signal-to-noise ratio (SNR) of the recorded signals and for the highest-yield shots can amount to a substantial fraction of the pixel's full well capacity. The problem is worse for streak camera diagnostics because of their inherent luminous gain. In Fig. 2 we present data from one of the streak cameras that monitor the UV pulse shape in OMEGA. This camera is located 11.2 m from the target chamber center. As shown in Fig. 2, for a non-fusion target (blue curve), the dynamic range of the recorded signal is nearly 1000, and the SNR at the peak of the pulse is 100. For a target shot producing 1.0 $\times$ 10^{13} DT neutrons, however, in Fig. 2 (red curve), the dynamic range is reduced to <10 and the SNR at the peak is <5. Only a small fraction of the CCD background level is produced by the direct interaction of the neutrons with the CCD chip itself; most of it is due to down-scattered neutrons and MeV gamma rays. These originate from interactions of the primary neutrons with all materials in the Target Bay, making it very challenging to shield the diagnostics. To ameliorate this problem for the yields expected on the NIF, improved shielding, larger distances, and time-gated imaging systems will be required.

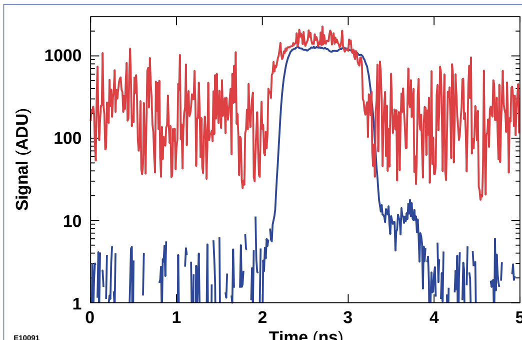

Figure 2. Streak camera recordings for no yield (blue) and high-neutron yield shots (red).

OMEGA Operations Summary: In January OMEGA shots were divided among three weeks of internal ISE campaigns and one week of LANL shots; there were 89 total shots. Power balance iterations and illumination uniformity experiments were combined with spherical implosions in over 56 LLE target shots. During the LANL week there were two campaigns: direct-drive cylinders (20 shots) and backlighter development (13 shots).

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